United States Government

Department of Energy
Portsmouth/Paducah Project Office

memorandum

DATE: 2 2 SEP 2004

REPLY TO
ATTN OF: PPPO:KOZLOWSKI

PPPO-01-645-04

SUBJECT: **PORTSMOUTH /PADUCAH PROJECT OFFICE SOFTWARE QUALITY ASSURANCE IMPLEMENTATION PLAN COMPLETION**

TO: Paul Golan, Acting Assistant Secretary

On December 18, 2003, I provided a response to the Office of Environmental Management memorandum concerning the Defense Nuclear Facilities Safety Board (DNFSB) recommendation on Software Quality Assurance (SQA) Implementation Plan. This response indicated that additional time was required to complete the SQA assessment identified in commitments 4.2.3.2 and 4.2.4.2. Attached is our report that completes these stated actions. We have provided this report to our contractors to address the three findings included in the report.

Commitment 4.1.3 required our office to identify the Federal positions whose duties and responsibilities require them to provide assistance, guidance, direction, oversight or evaluation of safety software QA activities. As you are aware, we are currently transitioning functions from the Oak Ridge Office to the Portsmouth/Paducah Project Office. Until this transition is completed, our office will rely on Ms. Teresa Perry, DOE/ORO, to be our lead for safety software QA activities. We plan on utilizing Mr. Jack Zimmerman as our lead for safety software QA activities once he has completed the safety software QA qualification standard.

If you have any questions concerning this, please contact me at (859) 219-4000 or have a member of your staff contact David Kozlowski at (859) 219-4009.

William E. Murphie
Manager
Portsmouth/Paducah Project Office

Attachment

cc: w/o Attachment
I. Triay, EM-3
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J. Vaughn, EM-20
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U.S. Department of Energy
Portsmouth & Paducah Project Office

Assessment of Bechtel Jacobs Company LLC
Safety Software Quality Assurance Processes

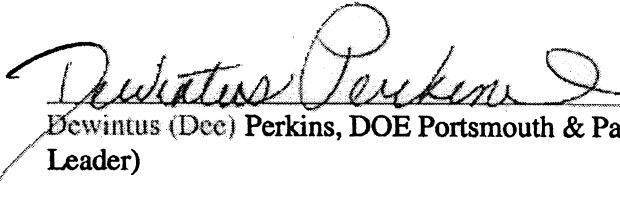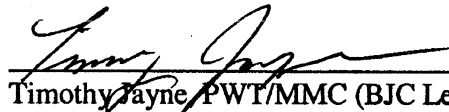# May 18 – June 25, 2004 (SCALE)

July 26 – 30, 2004 (MACCS)

Final Report

August 2004

U. S. Department of Energy
Portsmouth & Paducah Project Office
Assessment of the Bechtel Jacobs Company LLC
Safety Software Quality Assurance Processes

Report Approval

Dewintus (Dee) Perkins   _9-21-04_

Dewintus (Dee) Perkins, DOE Portsmouth & Paducah Project Office (Team Leader)

Timothy Jayne   _9-21-04_

Timothy Jayne, PWT/MMC (BJC Lead)

Signature on File

Teresa Perry, DOE Oak Ridge Operations Office
(Software Quality Assurance Subject Matter Expert
for the MACCS Review)

APPROVED:

William Murphie   _9-22-04_

William Murphie, Manager
DOE Portsmouth & Paducah Project Office

Table of Contents

List of Acronyms

BJC	Bechtel Jacobs Company LLC
COTS	Commercial Off-The-Shelf
CD	Compact Disc
CFR	Code of Federal Regulations
CRAD	Criteria Review and Approach Document
CTF	Cognizant Technical Function
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
DNFSB	Defense Nuclear Facilities Safety Board
EM	Environmental Management
ES&H	Environment, Safety, and Health
IEEE	Institute of Electrical & Electronics Engineers
MACCS	MELCOR [Methods for Estimation of Leakages and Consequences of Releases] Accident Consequence Code System
NCS	Nuclear Criticality Safety
NISYS	NISYS Corporation
NQA	Nuclear Quality Assurance
ORO	Oak Ridge Operations Office
PPPO	Portsmouth & Paducah Project Office
QA	Quality Assurance
RSICC	Radiation Safety Information Computational Center
SCALE	Standardized Computer Analyses for Licensing Evaluation
SDD	Software Design Description
SQA	Software Quality Assurance
TVA	Tennessee Valley Authority
V&V	Verification and Validation
WSMS	Washington Safety Management Solutions Mid-America

U. S. Department of Energy
Portsmouth & Paducah Project Office
Assessment of the Bechtel Jacobs Company LLC
Safety Software Quality Assurance Processes

Executive Summary

The Portsmouth & Paducah Project Office conducted an assessment of the safety Software Quality Assurance (SQA) processes of its prime contractor, Bechtel Jacobs Company LLC (BJC), during the period May 18–June 25 and July 26–July 30, 2004. The assessment was undertaken to fulfill the field office's commitments in the U.S. Department of Energy (DOE) Implementation Plan, *Quality Assurance for Safety Software at Department of Energy Defense Nuclear Facilities,* for Defense Nuclear Facilities Safety Board Recommendation 2002-1.

The objective of the assessment was to assess the adequacy of SQA for software used in the safety analysis and design of nuclear facilities. The assessment was based on one of the criteria review and approach documents developed by the DOE Office of Assistant Secretary for Environment, Safety and Health to specifically address these objectives. The following six areas were included in this SQA assessment:

- Software Requirements Description
- Software Design Description
- Software User Documentation
- Software Verification and Validation (V&V)
- Software Configuration Management
- Software Quality Assurance
- Software Reporting and Corrective Action

The safety analysis and design work for nuclear facilities is performed by Westinghouse Safety Management Solutions Mid-America (WSMS) and NISYS Corporation (NISYS) personnel through BJC's subcontractor, WSMS, Inc. Therefore, the assessment addressed safety analysis and design computer software programs for the following two systems that are controlled and used by personnel from WSMS and NISYS, respectively:

- MELCOR [Methods for Estimation of Leakages and Consequences of Releases] Accident Consequence Code System (MACCS)

- Standardized Computer Analyses for Licensing Evaluation (SCALE) computational system

The SCALE computational system is a modular system consisting of a driver module, control modules, functional modules, utility modules, data libraries, and subroutine libraries. The SCALE system draws heavily from basic neutron-transport, data-processing, and heat-transfer methods technology developed at the Oak Ridge National Laboratory over the past three

decades. It is designed for evaluating the criticality, shielding, and thermal aspects of nuclear fuel facility and/or spent fuel cask designs.

MACCS is a fully integrated, engineering-level computer code whose primary purpose is to model atmospheric transport of radioactivity released under postulated accident conditions, and the subsequent uptake and resulting consequences to human receptors.

The assessment team found that the designated principal users of safety software in both organizations have excellent qualifications and experience. The team concluded that all of the criteria have been met for using the SCALE code. For the MACCS code, all of the criteria have been met, with the exception of configuration management of the user documentation and media and documentation of user training. The noteworthy practices, findings, observations, and areas for continuous improvement identified during this assessment are listed below.

Noteworthy Practices

NP-1: The WSMS designated Senior Users and Users of software have excellent qualifications and experience.

NP-2: The WSMS Senior User of MACCS has expert knowledge of the software use, assumptions, limitations, and source code, and she shares her knowledge by mentoring other MACCS users.

NP-3: WSMS has developed a good set of training materials for the MACCS system that were presented at a DOE Energy Facility Contractors Group meeting and are routinely provided to all WSMS MACCS users.

NP-4: NISYS has implemented its SQA program for SCALE 4.4a in two procedures that capture all of the requirements in an easy-to-follow, concise manner.

NP-5: NISYS and BJC have included training and qualification on the use of SCALE4.4a as a part of the qualification card requirements for nuclear criticality safety engineers.

Findings

F-1: WSMS has not adequately documented its training and qualification program for the Users and designated Senior Users of MACCS.

F-2: WSMS has not adequately implemented software configuration control for MACCS.

F-3: The WSMS procedure for configuration control of MACCS is not approved.

Observations

None.

Areas for Continuous Improvement

The following areas for continuous improvement are provided for consideration. These items are intended to be suggestions for improving efficiency and/or quality and are not considered to be deficiencies.

CI-1: BJC has not required or requested WSMS to provide a copy of the MACCS code V&V hand calculations (which leaves BJC and DOE vulnerable if the subcontract is terminated).

CI-2: BJC has not required or requested WSMS to provide electronic copies (either Acrobat PDF or Word format) of the MACCS calculation hard copy package, which would facilitate rerunning the code, if needed.

CI-3: MACCS is a DOS-based code, and its functionality could be improved by revising the code to run in a Windows-based environment.

CI-4: User manipulation of MACCS output could be reduced and efficiency improved by having a program option for units conversion. Currently, only SI units are available for program output format.

CI-5: Code output requires manual manipulation to add multiple cases. This function needs to be automated and streamlined to improve functionality.

U. S. Department of Energy
Portsmouth & Paducah Project Office
Assessment of the Bechtel Jacobs Company LLC
Safety Software Quality Assurance Program

1.0 INTRODUCTION

This report presents the results of a Portsmouth & Paducah Project Office (PPPO) assessment of the safety Software Quality Assurance (SQA) processes of its prime contractor, Bechtel Jacobs Company LLC (BJC). The assessment was conducted during the period May 18–June 25 and July 25–July 30, 2004. The background and objectives of the assessment are discussed below.

1.1 Background

In May 2003, the Secretary of Energy, Spencer Abraham, authorized the establishment of a new Environmental Management (EM) Project Office. The PPPO in Lexington, Kentucky, was established to support the Secretary's accelerated cleanup plan at both sites. The PPPO is identified as a project office in recognition that the EM cleanup functions are temporary. The PPPO performs oversight of Environment, Safety, and Health (ES&H) and of safeguards and security for all EM cleanup activities. It provides a day-to-day Federal presence at both sites to focus on the accelerated cleanup at the Portsmouth and Paducah Sites and the other uranium activities currently performed by EM. The Portsmouth Site is located in Piketon, Ohio, and the Paducah Site is located in Paducah, Kentucky.

During 2002–2003, a comprehensive and detailed Documented Safety Analysis (DSA) was conducted at the Portsmouth and Paducah Sites for the Cylinder Yards and the Hazard Category 2 facilities located in Piketon, Ohio, and Paducah, Kentucky, respectively. This analysis examined the possible accident scenarios that could result from the operation of the Portsmouth and Paducah Cylinder Yards and the Hazard Category 2 facilities in order to provide prevention and mitigation as part of the facility operations. The scenarios were evaluated by analysis of (a) equipment designed to conduct the operations, prevent the release of the hazards, or mitigate abnormal conditions and (b) the procedures relied upon to implement the correct operation of the equipment and to convey to personnel the appropriate response to abnormal conditions. In addition, the scenarios were evaluated by examination of the characteristics of the possible accidents to determine whether the consequences could be mitigated without undue risk to the health and safety of the public and site personnel or to the environment.

The U.S. Department of Energy (DOE) Implementation Plan for Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 2002-1, *Quality Assurance for Safety-Related Software,* dated September 2002, defines the actions and processes that are being taken to ensure the quality of safety software at defense nuclear

facilities. Safety software includes both safety system software and safety analysis and design software. Commitment 4.2.3.3 of the Implementation Plan is to complete the identification, selection, and assessment of safety system software. Commitment 4.2.4.3 is to complete assessments of the processes in place to ensure that safety software currently used to support the analysis and design of defense nuclear facilities is adequate.

As PPPO's prime contractor, BJC is responsible for EM activities at the Portsmouth and Paducah Sites. The work involves the use of safety analysis and design computer codes in support of EM and restoration projects and waste management and disposition activities. The present assessment was undertaken to fulfill the above-mentioned commitments relative to safety software currently used by Westinghouse Safety Management Solutions Mid-America (WSMS) and NISYS Corporation (NISYS) personnel working as BJC's subcontractor for safety analysis services.

1.2 Objectives and Criteria

The primary objective of this assessment followed the objectives and commitments contained in the DOE Implementation Plan for DNFSB Recommendation 2002-1 to:

> "Assess the adequacy of BJC's SQA processes in place for computer codes, calculation software, and database programs, including custom and commercial off-the-shelf (COTS) software used in the safety analysis and design of nuclear facilities."

The assessment was based on Criteria Review and Approach Document (CRAD) 4.2.4.1, which was developed by the DOE to specifically address this objective.

The objectives and criteria in the CRAD are consistent with Title 10 Code of Federal Regulations (CFR) 830, Subpart A, "Quality Assurance Requirements," and DOE Order 414.1A, Attachment A, "Contractor Requirements Document on Quality Assurance," which are implemented in DOE's contract with BJC through the BJC Quality Assurance (QA) Program Plan.

1.3 Report Organization

The next two sections discuss the scope and approach of the assessment. Section 4 presents the significant results in terms of noteworthy practices, findings, and observations. Section 5 provides brief summaries of the assessment areas mentioned in the DOE CRAD, including whether the specified criteria have been met. These summaries cross-reference the findings and observations in Section 4 to indicate the issues identified in the assessment areas. Section 6 provides the overall conclusion of the assessment team. Appendices A and B are lists of the documents reviewed and the personnel interviewed, respectively, in support of this assessment. Appendix C provides brief biographies of the assessment team members relative to their qualifications and experience.

2.0 ASSESSMENT SCOPE

BJC's safety analysis and design work is performed by WSMS and NISYS through BJC's subcontractor, WSMS, Inc. WSMS personnel perform analyses for BJC through task-order contracts under their own approved QA plan. NISYS performs a staff augmentation function under the WSMS approved QA plans. For that reason the NISYS SQA effort implements WSMS 1Q 4-4.

The scope of this assessment was limited to the following DOE-supplied safety software:

- SCALE 4.4a (Standardized Computer Analyses for Licensing Evaluation)
- MACCS 1.5.11.1 (MELCOR [Methods for Estimation of Leakages and Consequences of Releases] Accident Consequence Code System)

The two software packages reviewed are part of the DOE-approved and -supplied software and are provided to approved users through the **R**adiation **S**afety **I**nformation **C**omputational **C**enter (RSICC), which is a DOE Specialized Information Analysis Center. Therefore, this assessment focused on SQA from a user basis rather than from a development and procurement basis.

3.0 ASSESSMENT APPROACH AND TAILORING

3.1 Software Identification and Selection

An initial step in this assessment, undertaken with BJC's assistance, was the development and review of BJC's and its subcontractor's inventory of software that potentially could be classified as safety software using the definitions in the DOE CRAD. This resulted in the selection of the software specified above. There were no safety class instrumentation and control software applications used at either the Portsmouth Site or the Paducah Site.

3.2 Software Assessment

The DOE CRAD for SQA assessment of safety analysis and design software identifies eight broad areas covering the typical software life cycle. These areas are as follows:

- Software Requirements Description
- Software Design Description (SDD)
- Software User Documentation
- Software Verification and Validation (V&V)
- Software Configuration Management
- SQA
- Software Procurement
- Software Reporting and Corrective Action

3

The criteria and approach in the CRAD required tailoring in certain areas. For example, the software requirements description and SDD areas do not fully apply to procured COTS software. V&V applies differently to COTS, so the assessment focused on installation V&V and proper validation using test problems and cases appropriately matched to the intended software application. The assessment team briefly addressed the subject area of software requirements and design. The subject area of software procurement was deemed not applicable to this assessment:

The qualification and training of software users was an important element in this assessment, especially for the relatively complex safety analysis and design codes where significant technical expertise is needed for proper code validation, problem modeling, and correct use of the software for diverse applications. The assessment criteria provided in the DOE CRAD do not address this aspect explicitly, although they refer to user training as part of one item in describing the approach for the software user documentation assessment area. The assessment team appropriately augmented its lines of inquiry in this assessment area to address software user qualifications and training in greater detail.

Document reviews and personnel interviews were the primary means of gathering data for the assessment. The full lists of documents reviewed and personnel interviewed are provided in Appendices A and B, respectively. The following are examples of the types of requirements and background documents reviewed:

- DOE and contractor SQA requirements documents
- Facility-specific SQA requirements and procedures
- List of databases that may have safety implications
- List of subcontractors using or developing safety software

The following are examples of types of software-specific documents reviewed:

- Software functional and requirements and descriptions
- Program description manuals, user manuals, guides, and instructions
- User qualification and training requirements/records and training manual(s)
- List of individuals that performed V&V and their qualifications
- List of authorized users

The following are examples of key personnel interviewed:

- Software users
- Discipline or functional manager
- Individuals responsible for software V&V
- Nuclear safety (authorization basis) engineers, as necessary

Prior to issuance, a draft of this report was provided to BJC and WSMS for a factual accuracy review. All review comments were addressed.

4.0 ASSESSMENT RESULTS

The following is a discussion of the noteworthy practices, findings, observations, and areas for continuous improvement derived from the team's assessment of the safety SQA processes of BJC, WSMS, and NISYS. Most of these results cut across several assessment areas; therefore, all of the essential information from each relevant assessment area that supports a given conclusion is included with each assessment result. Brief summaries of the assessment areas, with references to the results discussed below, are provided in the next section.

Overall, the assessment team found that BJC has established an adequate hierarchy of computer software requirements. Some instances of weaknesses in implementation for the MACCS software are described in Section 4.2 of this report. The assessment team concluded that all of the criteria have been met for the SCALE code usage. For the MACCS code, all of the criteria have been met, with the exception of configuration management of the user documentation and media and documentation of user training.

4.1 Noteworthy Practices

NP-1: The WSMS designated Senior Users and Users of software have excellent qualifications and experience.

NP-2: The WSMS Senior User of MACCS has expert knowledge of the software use, assumptions, limitations, and source code, and she shares her knowledge by mentoring other MACCS users.

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NP-5: NISYS and BJC have included training and qualification on the use of SCALE4.4a as a part of the qualification card requirements for nuclear criticality safety engineers.

4.2 Findings

Each finding is followed by a list of the requirements that were not met and a discussion.

F-1: WSMS has not adequately documented its training and qualification program for the Users and designated Senior Users of MACCS.

<u>Requirements Not Met</u>

(1)   BJC procedure BJC-HR-0712, *Training Records Management* Section A.5 states: "Maintain training and qualification records in a manner that supports verification of the program content and the assertion of an individual's qualification. Individual record documentation for nuclear, radiological, and high-moderate hazard facility qualified positions (identified in BJC/OR-1088) shall include the following at a minimum (reference BJC-HR-0724):

☐ Education, experience, and employment history and most recent health evaluation summary;

☐ Training programs completed and qualification achieved;

☐ Latest completed checklists and graded written examinations

☐ Lists of questions asked and the examiner's overall evaluation of the responses on oral examinations;

☐ Correspondence relating to exceptions to training requirements and extensions of qualification;

☐ Records of qualification for one-time-only special tests or operations;

☐ Attendance records for required training courses or sessions.

☐ A historical record that documents initial qualification, and applicable information (see first bullet in this list), that verifies the most recent qualification is retained in individual records.

<u>Discussion</u>

The finding in this area is based on the following deficiencies found in the MACCS training and qualification program:

- WSMS personnel stated that MACCS user training took place in November 2003. MACCS was used in 2003 to perform the analysis supporting the DSA for the Portsmouth and Paducah Sites; however, the documentation of the training is contained in correspondence dated June 24, 2004 (WSMS correspondence No. WSMSMA-04-1027). WSMS provided no employee training records to confirm that the training was completed prior to using the software to conduct the DSA analysis. Personnel interviewed were very knowledgeable of the MACCS software. The weakness is in the lack of formality in conducting and recording the training results. In summary, in-house training on the MACCS software is informal, no certificates are issued, and the user training is not part of the employee's training record. In addition, a review of the transmittal of MACCS software QA documentation from WSMS to Bechtel Jacobs (WSMS correspondence WSMSMA-03-0120) confirmed that the transmittal does not include documentation of MACCS user qualifications. Bechtel Jacobs has no record of the MACCS user qualifications and training on file as required by the Bechtel Jacobs procedure which WSMS must follow per the contract.

- In practice, WSMS distinguishes between Users and Senior Users of the MACCS software. WSMS staff interviewed explained that a Senior User is one who can

work unsupervised to perform calculations. A User is not considered to have adequate experience with using the code to perform calculations without oversight from a Senior User. The team reviewed a calculation package developed by a User and confirmed that A Senior User had co-authored the document. The determination and designation of Senior Users is an important part of the WSMS quality control process for calculations using MACCS, and the practice is considered by this assessment team to be part of a good process. The weakness lies in the informality of establishing Senior Users. WSMS has not clearly defined and documented the roles, responsibilities, and qualification requirements for Senior Users. It is left up to the latitude of the Cognizant Technical Function (CTF). WSMS has no document or procedure that describes its process for qualifying Users as Senior Users so that they can work unsupervised to perform calculations.

F-2: WSMS has not adequately implemented software configuration control for MACCS.

Requirements Not Met

(1) WSMS procedure WSMS-IQ 4-4, *Software Quality Assurance*, Section 6.0, states that "Records shall be controlled in accordance with the requirements of WSMS-IQ 4-3, Quality Assurance Records Management. The following shall be maintained as a QA record: . . . User documentation."

(2) BJC procedure BJC-OS-1001 *Records Management, Including Document Control,* Section I. 7 states: Use only an approved controlled copy in the performance of work.

(3) BJC procedure BJC-OS-1001 *Records Management, Including Document Control,* Section I. 7 states: Develop a tracking process to account for all issued controlled copies.
    a. Request transmittals be signed and returned to confirm the document is still needed by the controlled copy holder within a 21 day time period of the distribution.
    b. Issue delinquency notices for all outstanding transmittals and provide an additional 14 day time period to respond.
    c. Identify to the originator of the distribution list, the copy holder's supervisor, or the BJC Records Manager any copy holder that does not respond to the delinquency notice. Request assistance to resolve or directions on how to proceed. Decontrol the controlled copy only upon written direction from one of the aforementioned people or the copy holder himself.

(4) Title 10 CFR 830, Subpart A, Paragraph 122(e)(3), states, "Maintain items to prevent their damage, loss, or deterioration."

Discussion

This finding is based on the following deficiencies found in the configuration management of the MACCS software and documentation:

- The MACCS software configuration control guidance, WSMS-TR-03-0004, does not establish a control system for distribution of the user documentation, and the user control and identification of the MACCS manual and installation Compact Disc (CD) as QA documents.

- WSMS does not issue controlled user manuals and installation CDs for MACCS. Installation of the MACCS code at remote locations is not performed as described in WSMS-TR-03-0004. The QA version of the MACCS executable stored on the WSMS shared server is not easily retrievable or downloadable by users at remote sites, requiring the use of a CD copy for installation. To remedy this situation, the CTF provides a copy of the code to be installed using a CD. Using installation CDs created by the CTF is a good practice. The problem lies in not distributing controlled installation CDs and controlled user manuals to the authorized Users and Senior Users of the code, and the lack of a procedure that describes the process that is in use by WSMS.

- One WSMS MACCS User interviewed did not have user documentation for installation and use of MACCS Version 1.5.11.1, as required by WSMS 4-4, *Software Quality Assurance*. The User did have an uncontrolled copy of the documentation for MACCS2. However, this is further evidence of weakness in configuration control for user documentation and electronic media used for quality-related work, although configuration control is required by WSMS' procedures.

F-3: The WSMS procedure for configuration control of MACCS is not approved.

Requirement Not Met

WSMS procedure WSMS IQ 4-1, Section 4.1, states that "Job Function Managers shall be responsible for ". . . Ensuring that activities within their area of responsibility which affect quality are prescribed by and performed in accordance with documented instructions, procedures . . ." Section 5.0, Paragraph A.1, states that "Activities affecting quality shall be prescribed by and performed in accordance with documented instructions, procedures, or drawings . . . appropriate to the activities." Section 5.0, Paragraph B, states that "Procedures shall be developed, reviewed, and approved by the WSMS Procedural Document Process." Section 6.0 states, "Instructions, procedures, revisions, and review comments/dispositions shall be maintained in accordance with WSMS-1Q 4-3."

Discussion

No signed, issued procedure for MACCS software configuration and control was available to the assessment team at the time of the review. WSMS TR-03-0004 was not signed, dated, or approved in accordance with the WSMS requirements for documents governing quality-related activities. After the on-site review, WSMS subsequently signed, dated, and approved WSMS-TR-03-0004, Revision 0, on August 19, 2004, and Revision 1 on August 19, 2004.

4.3 Observations

None.

4.4 Areas for Continuous Improvement

The following areas for continuous improvement are provided for consideration. These items are intended to be suggestions for improving efficiency and/or quality and are not considered to be deficiencies.

CI-1: BJC has not required or requested WSMS to provide a copy of the code V&V hand calculations (which leaves BJC and DOE vulnerable if the subcontract is terminated).

CI-2: BJC has not required or requested WSMS to provide electronic copies (either Acrobat PDF or Word format) of the MACCS calculation hard copy package, which would facilitate rerunning the code, if needed.

CI-3: MACCS is a DOS-based code, and its functionality could be improved by revising the code to run in a Windows-based environment.

CI-4: User manipulation of MACCS output could be reduced and efficiency improved by having a program option for units conversion. Currently, only SI units are available for program output format.

CI-5: Code output requires manual manipulation to add multiple cases. This function needs to be automated and streamlined.

5.0 SUMMARY OF ASSESSMENT AREAS

The following section provides a summary of assessment areas by the QA topics covered in the DOE CRAD. The lists of documents reviewed and personnel interviewed were organized according to the organizations and the software applications selected for assessment. These lists are provided in Appendix A and B, respectively.

5.1 Software Requirements Description

<u>Objective</u>

Analysis and design software functions, requirements, and their bases are defined and documented.

<u>Criteria</u>

1. The functional and performance requirements for the analysis and design software are complete and detailed to perform software design.

2. The software design description is reviewed, controlled, and maintained.

3. Each requirement should be uniquely identified and defined such that it can be objectively verified and validated.

<u>Summary</u>

The criteria have been met. The MACCS 1.5.11.1 and SCALE 4.4a software have a long history of use, and the code requirements and basis for V&V are documented and published in the system documentation.

<u>Related Noteworthy Practices, Findings, and Observations</u>

None.

5.2 Software Design Description

<u>Objective</u>

The SDD depicting the major components of the software design is defined and documented.

<u>Criteria</u>

1. All software-related requirements are implemented in the design.
2. All design elements are traceable to the requirements.
3. The SDD is reviewed, controlled, and maintained.

Summary

The criteria have been met. The MACCS 1.5.11.1 and SCALE 4.4a software have a long history of use, and the code requirements and basis for the SDD are documented and published in the system documentation.

Related Noteworthy Practices, Findings, and Observations

None.

5.3 Software Verification and Validation

Objective

The software V&V process is defined and performed, and related documentation is maintained to ensure that (a) the software adequately and correctly performs all intended functions and (b) the software does not perform any unintended function.

Criteria

1. All analysis and design software requirements and software design have been verified and validated for correct operation using testing, observation, or inspection techniques.

2. Relevant abnormal conditions have been evaluated for mitigating unintended functions through testing, observation, or inspection techniques.

Summary

The criteria have been met. Reviews of the system documentation and supporting V&V calculations confirm that sufficient V&V of the MACCS and SCALE 4.4a software systems has been performed to ensure proper installation and that correct results are produced from the code. In addition, evidence of user training and interviews with system users confirmed that users are qualified to use the code as intended.

Related Noteworthy Practices, Findings, and Observations

None.

5.4 Software User Documentation

Objective

Software documentation is available to guide the user in installing, operating, managing, and maintaining the software.

<u>Criteria</u>

1. The system requirements and constraints, installation procedures, and maintenance procedures (such as database fine-tuning) are clearly and accurately documented.

2. Any operational data system requirements and limitations are clearly and accurately documented.

3. Documentation exists to aid the users in correct operation of the software and to provide assistance for error conditions.

4. Appropriate software design and coding documentation to assist in future software modifications is defined and documented.

<u>Summary</u>

MACCS – The criteria have been generally met, with the noted exceptions. Weaknesses exist in the control of the user documentation and media provided to MACCS users and are described in Section 5.5 and Finding 2 of this report pertaining to configuration control of the user documentation.

SCALE 4.4a – The criteria have been met. NISYS distributes the SCALE 4.4a software to the users on controlled CDs. All user documentation (including installation instructions, system requirements, V&V procedures, and limitations) is on the CD. A member of the assessment team reviewed the contents of one of the controlled CDs and determined that all of the requirements have been met.

<u>Related Noteworthy Practices, Findings, and Observations</u>

NP-3: WSMS has developed a good set of training materials for the MACCS system that were presented at a DOE Energy Facility Contractors Group meeting and are routinely provided to all WSMS MACCS users.

F-3: WSMS has not adequately implemented software configuration control for MACCS.

5.5 Software Configuration Management

<u>Objective</u>

Software components, products, and related documentation are identified and maintained, and changes to those items are controlled.

<u>Criteria</u>

1. All software components and products to be managed are identified.

2. For those components and products, procedures exist to manage the modification and installation of new versions.

3. Procedures for modifications to those components and products are followed.

<u>Summary</u>

MACCS – The criteria have not been met. Weaknesses exist in the implementation of configuration control of user documentation and media and are described in Findings F-3 and F-4.

SCALE 4.4a – The criteria have been met. Software configuration management for SCALE 4.4a is addressed in NISYS-1000-SQP003/R0, *Software Quality Assurance Plan for SCALE 4.4a*, Revision 0. The manuals for the code are provided to the user on a controlled installation CD. The source code is also available and on record at NISYS' offices. A secure set of SCALE 4.4a batch files, executables, and data libraries is maintained on selected NISYS personal computers and on the NISYS computer network under administrator control. Read only access is provided to NISYS employees on the NISYS computer network. Modification and replacement of batch files, executables, and data libraries is limited to the NISYS Software Configuration Manager after appropriate testing and verification documentation are completed. In addition, a controlled copy of the SCALE 4.4a users manual is maintained on the NISYS computer network in PDF format.

The installation of SCALE 4.4a on individual personal computers is via a CD with the controlled version of the code. Proper execution of the installation test files and documented comparison of the results to the controlled set of results are sufficient to demonstrate that the proper requirements have been met for the computer hardware, the operating system, and the SCALE version. Configuration control of the software as installed on users' personal computers is addressed in NISYS-1000-TR001, *SCALE 4.4a Verification Report*, Revision 1.

<u>Related Noteworthy Practices, Findings, and Observations</u>

F-3: WSMS has not adequately implemented software configuration control for MACCS.

F-4: The WSMS procedure for configuration control of MACCS is not approved.

5.6 Software Quality Assurance

Objective

SQA activities are evaluated for applicability to the analysis and design software, defined to the appropriate level of rigor, and implemented.

Criteria

1. The SQA activities and software practices for requirements management, software design, software configuration management, procurement controls, V&V (including reviews and testing), and documentation have been evaluated and established at the appropriate level for proper applicability to the software under assessment.

2. The SQA activities have been effectively implemented. (This includes verification that users have been adequately trained on the installation, use, and limitations of the software code.)

Summary

MACCS – The criteria have generally been met, with the noted exceptions. Weaknesses exist in the SQA activities for MACCS that hinder effective SQA implementation in the formality and documentation of the program and are described in Findings F-1 through F-3. A review of the report from a WSMS independent quality assurance assessment performed in 2003 (No. 2003-IAR-03) and discussion with the Lead Auditor confirmed that WSMS has performed an assessment of the MACCS software and other safety software.

SCALE 4.4a – The criteria have been met. The SQA requirements for SCALE 4.4a are addressed in NISYS-1000-SQP003/R0, *Software Quality Assurance Plan for SCALE 4.4a*, Revision 0. The specific criteria include the following:

- Personal Computer Requirements
- FORTRAN Requirements
- Library Requirements
- Acceptance Criteria
- Installation Verification
- Validation
- Maintainability and Security
- Programming Conventions
- Methods for Error Reporting and Corrective Action
- Software Training and User Qualification

The assessment team reviewed this document and other supporting documentation (such as training records, installation CDs, and verification reports) and conducted

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interviews with two users. Successful completion of the training is one of the BJC qualification card criteria for nuclear criticality safety engineers. The qualification documentation is maintained by BJC. The assessment team concluded that the requirements have been effectively implemented.

Related Noteworthy Practices, Findings, and Observations

NP-3: WSMS has developed a good set of training materials for the MACCS system that were presented at a DOE Energy Facility Contractors Group meeting and are routinely provided to all WSMS MACCS users.

NP-4: NISYS has implemented its SQA program for SCALE 4.4a in two procedures that capture all of the requirements in an easy-to-follow, concise manner.

NP-5: NISYS and BJC have included training and qualification on the use of SCALE4.4a as a part of the qualification card requirements for nuclear criticality safety engineers.

F-1: WSMS has not adequately documented its training and qualification program for Users and designated Senior Users of MACCS.

F- 2: WSMS has not adequately implemented software configuration control for MACCS.

F-3: The WSMS procedure for configuration control of MACCS is not approved.

5.7 Software Procurement

This subject area was not applicable to this review. The design codes for MACCS 1.5.11.1 and SCALE 4.4a were developed at Sandia National Laboratory and the Oak Ridge National Laboratory, respectively, and they were internally distributed for use by DOE and its contractors.

The earlier versions of the MACCS and SCALE codes used in the analysis of the Portsmouth and Paducah Sites need to be placed in the DOE Toolbox of codes along with the later versions that utilize the code and documentation from the earlier versions.

5.8 Software Problem Reporting and Corrective Action

<u>Objective</u>

Formal procedures for software problem reporting and corrective action for software errors and failures are established, maintained, and controlled.

<u>Criteria</u>

1. Practices and procedures for reporting, tracking, and resolving problems or issues identified in both software items and software development and maintenance processes are defined, documented, and implemented.

2. Organizational responsibilities for reporting issues, approving changes, and performing corrective actions are identified and effective.

<u>Summary</u>

MACCS – The criteria have been met. A review of WSMS-TR-03-0004, *Software Configuration and Control Guidance for MACCS 1.5.11.1*, Revision 0, confirmed that formal procedures for reporting, tracking, and resolving software errors are defined in WSMS documents and are implemented for the MACCS software. Organizational responsibilities for MACCS software problem reporting and corrective actions reside with the CTF. Interviews with the current and former MACCS CTFs confirmed that the WSMS CTF is fulfilling these responsibilities.

SCALE 4.4a – The criteria have been met. The process for error reporting and corrective actions is described in NISYS-1000-SQP003/R0, *Software Quality Assurance Plan for SCALE 4.4a*, Revision 0. Problems or apparent errors are reported to the Software Configuration Manager, who investigates and determines the impact of the problem. If it is determined that previous applications of the code are impacted, the problem is reported to the QA Manager, who in turn files a Corrective Action Report. The problem is then tracked in the NISYS Corrective Action System to final resolution. The Software Configuration Manager also informs the developer assigned to the problem.

It should be noted that no problems have been identified by the NISYS users of this code. The only changes made were those made by installing the patches provided by the software developer. These changes, and any potential future changes, are documented by revising NISYS-1000-TR001, *SCALE 4.4a Verification Report*, Revision 1. The corrective action process described above is the documented process. No problems were noted in the SCALE software problem reporting and corrective action process.

None.

6.0 CONCLUSION

The assessment team found that WSMS and NISYS have established procedures and plans to comply with 10 CFR 830, Subpart A, and other applicable QA standards. As noted earlier in this report, the designated principal users of the safety software have excellent qualifications and experience. Weaknesses were identified in the WSMS training program, the conduct of self-assessments, and in definition of the roles and responsibilities of users. The assessment team concluded that all of the criteria have been met for use of the SCALE code. For the MACCS code, all of the criteria have been met, with the exception of configuration management of the user documentation and media and documentation of user training.

In addition, the assessment team recommends that the earlier versions of the MACCS and SCALE codes used in the analysis of Portsmouth and Paducah Sites be placed in the DOE Toolbox of codes along with the later versions that utilize code and documentation from the earlier versions.

7.0 LESSONS LEARNED

The following summarizes the lessons learned for improving the future assessments of the BJC safety SQA assessment process:

- Provide for more planning time prior to conducting the assessment.

- Prior to the assessment, hold an assessment team meeting to receive an overview and familiarization session on the contractor's software application features and usage relative to the DSA.

- Have copies available and perform preliminary reviews of the contractor's procedures and documentation.

- Maintain the assessment team as a co-located team dedicated full time to the assessment. This would have enhanced the team's ability to complete the report quickly and reduced delays caused by competing routine work assignments.

8.0 REFERENCES

1. *Quality Assurance for Safety Software at Department of Energy Defense Nuclear Facilities*, Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 2002-1, U.S. Department of Energy, March 13, 2003.

2. *Assessment Criteria and Guidelines for Determining the Adequacy of Software Used in the Safety Analysis and Design of Defense Nuclear Facilities*, CRAD 4.2.4.1, Revision 3, U.S. Department of Energy, October 24, 2003.

3. BJC/OR-43, *Bechtel Jacobs Company LLC Quality Assurance Program Plan for Environmental Management and Enrichment Facilities at Oak Ridge, Tennessee*, Revision 2, approved April 1, 2004, effective July 23, 2004

4. *Quality Assurance Requirements for Computer Software for Nuclear Facility Applications*, NQA-1, Subpart 2.7, American Society of Mechanical Engineers. [The BJC QA Program Plan, Section 2.8, refers to this document but does not specify a specific version.]

Appendix A – Documents Reviewed

BJC Documents

1. BJC-OS-1001, *Records Management, Including Document Control*

2. *BJC-OS-1005, Management of Subcontractor Submittals*

3. BJC-HR-0712, *Training Records Management*

4. BJC-HR-0702, *Training Program*

5. BJC-HR-0724, *Training and Qualification Program for BJC Category 2 and 3 Nuclear Facilities*

WSMS Documents

1. WSMS Interoffice Correspondence, WSMS-SAE-M-01-0022, from J.M. East to W.R. Mangiante, Subject: "Transfer of MACCS Code from the SRTC Alpha Cluster to WSMS Personal Computers," February 27, 2001.

2. WSMS Interoffice Memorandum from Kevin O-Kula to J. M. East and others, Subject: "MACCS Version 1.5.11.1 User Proficiency," October 27, 2003.

3. WSMS Correspondence WSMSMA-04-1027, from Jackie East, WSMS Paducah Program Manager, to Kevin O'Kula, Subject: "MACCS 1.5.11.1 Users at WSMS Mid-America," June 24, 2004.

4. WSMS Correspondence WSMSMA-03-0120, from Douglas Heal, Program Manager, to Gary Heidel, Bechtel Jacobs Company, LLC, Subject: "Software Quality Assurance Package for Nuclear Criticality," July 18, 2003. [MACCS SQA documentation transmittal]

5. WSMS Correspondence WSMSMA-03-0051, from Douglas Heal, Program Manager, to Bruce Wilson, Bechtel Jacobs Company, LLC, Subject: "Transmittal of Software QA Documentation for MACCS, ALOHA, and Hotspot Computer Codes," March 20, 2003.

6. E&CSD Correspondence from S. T. Gough to DBA File, Subject: "992W-1, ECS-DBA-95-0040, Rev. 0, Software Quality Assurance & Software Management Report for MACCS Version 1.5.11.1 (U), Revision 0," February 15, 1995.

7. E&CSD Correspondence from S. T. Gough to File, Subject: "N-SVR-S-00010, Software Quality Assurance Package for MACCS (U)," February 10, 1995.

8. E&PD Correspondence from S. T. Gough to File, Subject: "S-SQP-S-00006, MACCS Software Quality Assurance Plan (U)," January 4, 1995.

9. Draft document WSMS Calculation Number WSMSC-04-0019, Project MACCS SQA, "Installation of MACCS, Version 1.5.11.1 on Personal Computer with the Serial Number 3912A578 (U)."

10. WSMS Calculation WSMSC-03-0011, Project MACCS SQA, *Installation of MACCS, Version 1.5.11.1 on WSMS Computer Network*, March 6, 2003, pp. 553.

11. WSMS 1Q, *WSMS Quality Assurance Manual*, July 2003.
    - WSMS-1Q, 1-1, *Quality Assurance Program*, Revision 0.
    - WSMS-1Q, 2-1, *Personnel Training, Qualification, and Certification*, Revision 0.
    - WSMS-1Q, 3-1, *Correction of Significant Conditions Adverse to Quality*, Revision 1.
    - WSMS-1Q, 3-2, *Quality Improvement*, Revision 1.
    - WSMS-1Q, 4-1, *Instructions, Procedures, and Engineering Documents*, Revision 1.
    - WSMS-1Q, 4-2, *Document Control*, Revision 1.
    - WSMS-1Q, 4-3, *Quality Assurance Records Management Program*, Revision 2.
    - WSMS-1Q, 4-4, *Software Quality Assurance*, Revision 1.
    - WSMS-1Q, 6-1, *Design and Analysis Control*, Revision 1.
    - WSMS-1Q, 9-1, *Management Assessment*.
    - WSMS-1Q, 10-1, *Quality Assurance Assessment*.

12. Draft document WSMS-TR-03-0004, "*Software Configuration and Control Guidance for MACCS 1.5.11.1*," Revision 0, July 20, 2004 (unsigned/unapproved).

13. 2001-QAPLAN-001, *Project Specific Quality Assurance Plan for the Performance of Radiological Engineering for Bechtel Jacobs Company, LLC*

14. 2001-QAPLAN-002, *Project Specific Quality Assurance Plan for the Performance of Nuclear Criticality Safety Analysis for Bechtel Jacobs Company, LLC*

15. 2001-QAPLAN-003, *Project Specific Quality Assurance Plan for the Performance of Nuclear Safety Work for Bechtel Jacobs Company, LLC*

16. WSMS-TR-03-0021, *Software Quality Assurance Implementation Checklist for MACCS Version 1.5.11.1*, Revision 0, October 20, 2003.

17. WSMS-supplied uncontrolled document SED-AP-002, *Software Management and Quality Assurance Implementation Checklist*, Revision 0.

18. 2003-IAR-03, *Independent Quality Assurance Assessment of Nuclear Safety and Nuclear Criticality Safety Analysis, WSMS Mid-America Work for Bechtel Jacobs Company, LLC*, dated December 8, 2003.

19. WSMS Security Control Procedure, R1, approved October, 2003 by Jim Little, President.

20. WSMS Desktop Instructions for performing backups of the WSMS File and Print Server [where MACCS and other safety software reside].

21. Calculations performed to qualify MACCS Senior User interviewed:
    a. Calculation Number: S-CLC-K00164, Project: HEU Blend Down Project Safety Documentation
    b. Calculation Number: S-CLC-H-00681, Project: CLWR-TEF Authorization Basis Documentation
    c. Calculation Number: S-CLC-F-00307, Project: 235—F Vault Safety Analysis

WSMS Software Applications

MACCS 1.5.11.1 (MELCOR Accident Consequence Code System), which is a "Code System for simulating the Calculation of Reactor Accident Consequences on the surrounding environment by atmospheric transport"

NISYS Documents

1. *Quality Assurance Manual.*

2. NISYS-1000-SQP003, *Software Quality Assurance Plan for SCALE Version 4.4a*, Revision 0.

3. NISYS-1000-TR001, *SCALE 4.4a Verification Report*, Revision 1.

4. NISYS Corporation Computer Verification Certificate for Personal Computer DPY4K11.

5. NISYS Corporation Computer Verification Certificate for Personal Computer 76VBJO1.

6. NISYS Corporation Computer Verification Certificate for Personal Computer DELL_BJR.

7. NISYS Corporation Computer Verification Certificate for Personal Computer USW3240548.

8. NISYS-1000-TR002/R1, *Validation of SCALE Version 4.4a for the 27-GroupENDF/B-IV and 238-Group ENDF/B-V Cross Section Libraries for Uranium-233*, Revision 1.

9. RSICC Code Package Abstract CCC-545 SCALE 4.4.

10. Qualification Records for 5 SCALE 4.4a Users and the Software Configuration Manager.

NISYS Software Applications

SCALE 4.4a, which is a "Modular Code System for Performing Criticality and Shielding Assessment for Licensing Evaluation."

Appendix B – Personnel Interviewed

WSMS

- Senior Fellow Engineer and current CTF for MACCS software *(interviewed by telephone)*
- Program Manager, former CTF for MACCS, and a current MAACS User
- Senior Engineer and a MACCS User
- Quality Assurance Manager
- Information Technology Manager *(interviewed by telephone)*
- Lead Auditor for the WSMS Independent Quality Assurance Assessment of Nuclear Safety and Nuclear Criticality Safety Analysis *(interviewed by telephone)*

NISYS
- Senior Nuclear Criticality Safety Engineers (2)

Appendix C – Assessment Team Qualification and Experience Summaries

Dewintus (Dee) Perkins – DOE Assessment Team Leader

Ms. Perkins has conducted assessments and surveillances in various areas within the environmental restoration and remediation area. She assisted the Headquarters Environment, Safety, and Health Investigation Team examine the concerns of past operations, work practices, and current management of legacy materials at the Portsmouth and Paducah Sites.

DOE PPPO (Piketon, Ohio) Facility Representative	10/2003–Present
DOE Oak Ridge Operations Office (ORO), Environmental Management Project (Oak Ridge, Tennessee) Facility Representative	10/2000–10/2003
Environmental Engineer, Environmental Restoration General Engineer	6/1993–10/2003 9/1991–6/1993

Timothy D. Jayne – BJC Assessment Lead

Mr. Jayne has been leading and participating in quality assurance assessments and surveillances since 1993. This includes nine years with the United States Enrichment Corporation leading audits and managing the audit program under both DOE and Nuclear Regulatory Commission regulatory requirements.

McDonald Consulting Corporation, Knoxville, Tennessee (Portsmouth)   3/2003–Present
Quality Engineer, Lead Auditor

United States Enrichment Corporation, Portsmouth, Ohio   9/1970–8/2002
     Group Manager Independent Assessments (2001–2002)
     Subject Matter Expert for Audits
     Senior Staff Auditor/QA Specialist (1993–1999)
     American Society of Quality Certified Quality Auditor (1993–1999)
     Technical Advisor, Maintenance Engineering (1992–1993)

Teresa Perry – DOE Team Member and SQA Subject Matter Expert

Ms. Perry is the Quality Assurance Team Leader and a Lead Environmental Engineer for the Office of Assistant Manager for Environment, Safety, and Health, DOE Oak Ridge Operations. She has led and performed assessments for over 25 years in engineering and leadership positions

and is a certified NQA-1 Lead Auditor, a trained DOE Accident Investigator, and a trained DOE Employee Concerns Investigator. Her key assessment experience, professional experience and education are listed below.

Key Assessment and SQA Experience
- Completed the 40-hour Institute of Electrical & Electronics Engineers (IEEE) course, *IEEE Standards Seminar on Software Quality Assurance* (prior to joining DOE)
- Board Chairperson for DOE Type B Accident Investigation of Employee Foot Injury at BNFL Inc., in Oak Ridge, Tennessee (2004)
- Team Leader for the ORO Management Self-Assessment for Salt Removal at Molten Salt Reactor Experiment (2004)
- Team Leader for the Safety Management Programs Review of Bechtel Jacobs Company LLC (2003)
- Team Leader for the Operational Readiness Review of the Depressurization of the Sodium Fluoride Traps in Building 4501 at the Oak Ridge National Laboratory (2002)
- Team Leader for the Operational Readiness Review of the Bldg 3019A U^{233} Inspection and Repackaging Phase I Activities at the Oak Ridge National Laboratory (2001)
- Team Leader for the ORNL Radiation Protection Program Review and Employee Concern Investigation (2001)
- Assistant Team Leader and SQA Subject Matter Expert (reviewed configuration management of Green Salt Database) for the Operational Readiness Review of the Enriched Uranium Operations Metal Reduction and Primary Extraction Pour-Up Operations at the Y-12 National Security Complex (2001)
- Team Member and SQA Subject Matter Expert (reviewed numerical control software and equipment maintenance/calibration database) for the Readiness Assessment of the Startup of the Phase II Disassembly Activities at the Y-12 National Security Complex (2001)
- Board Member for DOE Type B Investigation of Subcontractor Employee Injuries From a Fall Accident at the Oak Ridge National Laboratory (2000)
- Program Manager for the ORO Environmental Restoration Division's development and production release of the Oak Ridge Environmental Information System, which is the ORO EM database that manages over 7 million records of environmental sampling data and GIS mapping data
- Computer Specialist, DOE ORO Information Resources Management Division (on detail for one year to perform ORO Business Continuity Planning and oversee Y2K readiness preparation for critical and safety software systems supporting ORO) (1999)
- Wrote procedures and guidance on software quality assurance for the Tennessee Valley Authority (TVA) nuclear engineering design software and audited software vendors for compliance with 10 CFR 50, Appendix B, and 10 CFR 21 error reporting requirements
- Group Manager for TVA Information Systems performing software development and maintenance and having responsibility for the TVA Office of Engineering Computer Systems Configuration Management Library, which houses over 150 computer systems used to support the design and construction of nuclear powerplants
- Programmer and Section Leader on development and deployment of the TVA Nuclear Computer-Aided Pipe Support Design Project

Professional Experience

- DOE ORO, Oak Ridge, Tennessee   1992–Present
  Most recently:
  QA Team Leader, Office of ES&H (2002–Present)
  Assessment Team Leader, Office of ES&H (2000–2002)
- Bechtel National, Oak Ridge, Tennessee   1990–1992
  Senior Engineer supporting the Special Projects Office and FUSRAP.
  Wrote computer code to design sampling plan for validation
  of polychlorinated biphenyl spill cleanup attainment.
- Tennessee Valley Authority, Knoxville, Tennessee   1977–1990
  Most recent position held:
  Manager of Services, Office of Engineering in Nuclear Power,
  which included Quality Assurance, Computer Applications, and Configuration
  Management for the Office of Engineering (1989–1990)

Education
- Master of Science in Environmental Engineering
- Master of Engineering in Civil Engineering
- Bachelor of Science in Civil Engineering
- Bachelor of Arts in Liberal Arts

DOE Technical Qualification Program
- General Technical Base – Completed
- Quality Assurance- Completed
- Environmental Restoration – Completed
- Safety Software Quality Assurance – In process
- ORO Assistant Manager for ES&H and Emergency Management– Completed
- ORO Safety Basis - Completed